ordination
23.) locate all LMDS transmitters below building roof tops
24.) prohibit blanket licensing of terrestrial facilities or satellite earth stations

5.11 Mitigation Opportunities Identified in WG1/67 (NRMC/86)

The following mitigation opportunities were suggested to be of general use in document WG1/67 (NRMC/86), and are included in this report to provide a complete summary of the mitigation opportunities mentioned during this negotiated rule-making proceeding.

To reduce interference to satellite receivers:
FSS:
Increase Power
Increase Allowable Io
Partial Band Use
LMDS:
Decrease Power
Lower Power Density Emitted by Changing Cell Size
Improved Antenna Sidelobes
Partial Band Use

To reduce interference to LMDS receivers:
FSS:
Decrease Power
Shielding/Absorbing
Lower Antenna Sidelobes
Blockage (?)
Partial Band Use
LMDS:
Increase Power
Shielding/Absorbing
Lower Antenna Sidelobes (some help)
Increase Allowable Interference
Blockage (?)
Partial Band Use

5.12 Mitigation Summary

Mitigation factors and opportunities were identified in eight different categories. In addition, other potential mitigating factors were mentioned. Many of the mitigation factors were not explored in sufficient depth to identify and implement adequate solutions. Other techniques that were explored did not individually provide enough mitigation to solve the problem. There is no guarantee that mitigation techniques alone will be sufficient to solve the interference problem of FSS uplinks interfering with LMDS receivers.

6.0 Introduction

Sections 6.1 - 6.4 contain summary results of the interference analysis scenarios that were the responsibility of Working Group 1. These results are based on the system characters provided by each proponents as reflected in Section 2.3 of this document. No independent verification of system parameters were performed by this Working Group. The analysis methods used are discussed in Section 4 of this document. It should be further noted that these analyses were generated under idealized free space assumptions which do not reflect factors such as building blockage, signal reflection, foliage attenuation, etc.

6.1 FSS Earth Stations Accessing GSO Satellites Interfering into LMDS Receivers

A MATLAB computer program was developed to calculate the required protection distance between an LMDS receiver and an FSS transmitter. All combinations of LMDS and FSS systems were considered.

The following equations describe this analysis (all parameters are in dB):

LMDS Link

$$C_l = EIRP_l + L_l + Gr_l(0)$$

$$N_l = k + Ts_l + BW_l$$

$$CNR_l = C_l - N_l$$

where:

C_l = LMDS carrier power
$EIRP_l$ = LMDS transmit EIRP
L_l = space loss for LMDS receiver located at the cell edge
$Gr_l(0)$ = LMDS receiver peak gain
N_l = LMDS receiver noise power
k = Boltzman's constant
Ts_l = LMDS receiver noise temperature
BW_l = LMDS signal bandwidth
CNR_l = LMDS carrier-to-noise ratio for a receiver at the cell edge

Allowed Interference

$$CIR_l = -10\log(1/10^{\wedge}(CNIR_l/10) - 1/10^{\wedge}(CNR_l/10))$$

$$I = C_l - CIR_l + \text{maximum}(0,(BW_f - BW_l))$$

where:

CIR_l = LMDS allowed carrier-to-interference ratio
$CNIR_l$ = LMDS allowed carrier-to-noise-plus-interference ratio
I = Allowed interference power
$\text{maximum}(0,(BW_f - BW_l))$ = Bandwidth ratio for cases where the interfering signal bandwidth is greater than the wanted signal bandwidth
BW_f = FSS signal bandwidth

Protection Distance

$$L_f = I - EIRP_f(\phi) - Gr_l(\theta)$$

$$d = \lambda/(4\pi * 10^\wedge(L_f/20))$$

where:

L_f = Allowed space loss between the LMDS receiver and the FSS transmitter
$EIRP_f(\phi)$ = FSS EIRP at the angle in the direction of the LMDS receiver
= FSS transmit power per channel + FSS transmit antenna gain in the direction of the LMDS receiver
$Gr_l(\theta)$= LMDS receiver gain in the direction of the FSS transmitter
d = Protection distance, meters
λ = Wavelength, meters

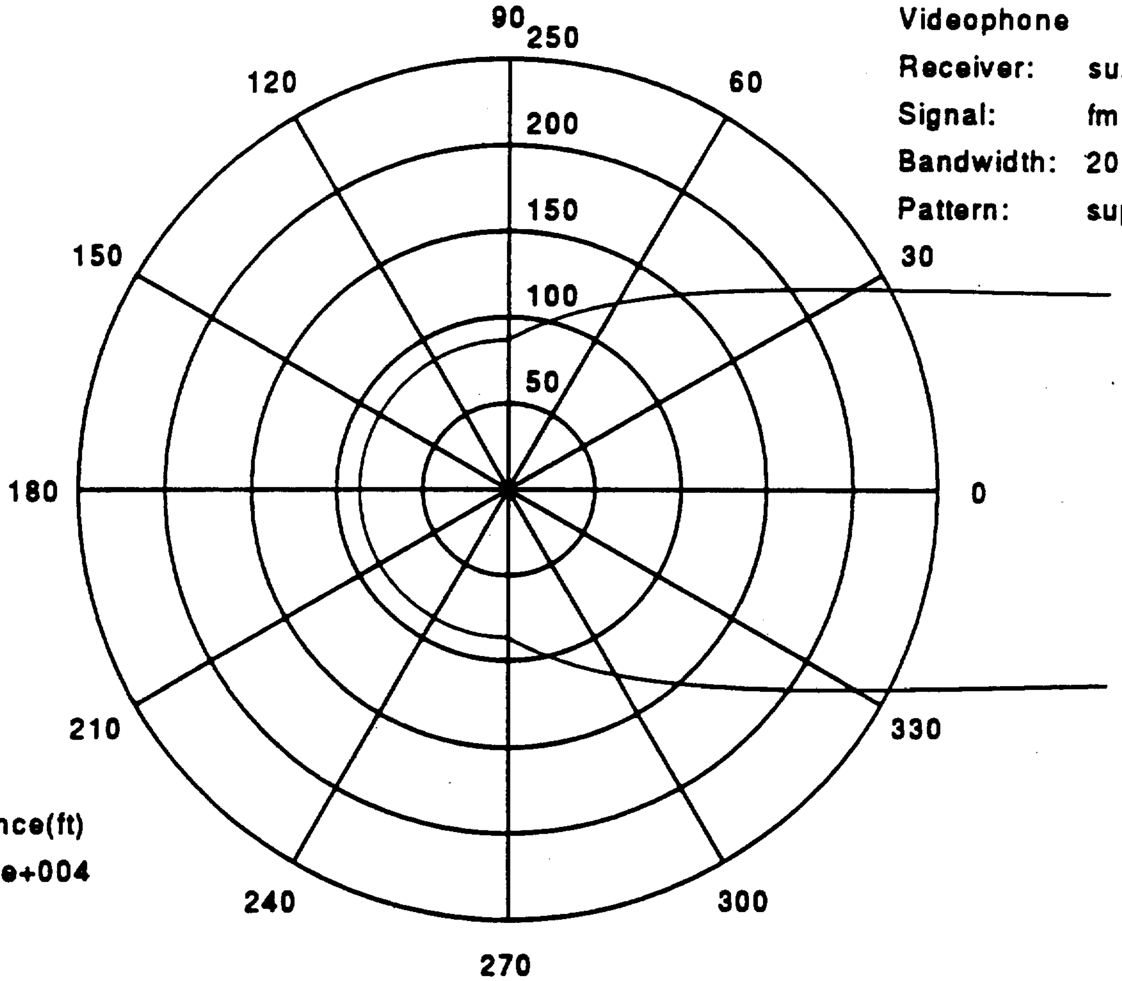
The MATLAB files are included as Attachment L and include proponent supplied values for the parameters used in this analysis.

A matrix of cases was considered with each FSS system interfering with each LMDS system. A sample of the output is shown as Figure 6.1-1. This case represents a Teledesic TST terminal interfering with a VideoPhone subscriber receiver. The LMDS receiver is located at the center of the polar plot and is oriented toward 0 degrees. The plot shows the minimum distance from the VideoPhone receiver that the Teledesic terminal must be located as a function of the LMDS receiver azimuth angle to maintain the require protection criteria. The plot clearly shows the increase in protection distance as the FSS terminal is located from the LMDS backlobe (180 degrees), through the sidelobe, and into the main beam (0 degrees). The protection distance at three angles is reported in the bottom left of the chart: 0 degrees is for the LMDS main beam, 45 degrees is for the first sidelobe, and 180 degrees is for the minimum backlobe. Table 6.1-1 summarizes the protection distance at these three angles for each interference case. Entire results are shown in Attachment M.

Figure 6.1-1

Protection Distance (ft) Case: 1 Teledesic into Videophone

Teledesic	
Terminal:	tst
Signal:	t1
Bandwidth:	26.5
Pattern:	itu
El. angle:	40



Videophone	
Receiver:	subscriber
Signal:	fm
Bandwidth:	20
Pattern:	supplied

Angle	Distance(ft)
0	3.444e+004
45	162
180	87

Table 6.1-1
Protection Distance (ft)
for FSS Uplinks into LMDS Receivers
Clear Sky Results

FSS System				VideoPhone					
				Subscriber FM			Hub 45 Mbps		
Name	Terminal	Data Rate	El. Angle	Mainlobe	Sidelobe	Backlobe	Mainlobe	Sidelobe	Backlobe
Teledesic	TST	T1	40	34440	162	87	53380	1069	646
Teledesic	TGT	OC24	40	2839	13	7	4401	88	53
Spaceway	Subscriber	T1	30	35270	165	89	51540	1032	624
ACTS	USAT	4.8 kbps	30	18090	85	45	26430	529	320
ACTS	HDRT	622 Mbps	30	49280	231	124	76380	1529	925

FSS System				Suite 12					
				Subscriber FM			Hub 40 kbps		
Name	Terminal	Data Rate	El. Angle	Mainlobe	Sidelobe	Backlobe	Mainlobe	Sidelobe	Backlobe
Teledesic	TST	T1	40	124600	7864	394	2664	2664	2664
Teledesic	TGT	OC24	40	10270	648	32	220	220	220
Spaceway	Subscriber	T1	30	134500	8488	425	8627	8627	8627
ACTS	USAT	4.8 kbps	30	68990	4353	218	31280	31280	31280
ACTS	HDRT	622 Mbps	30	178300	11250	564	3812	3812	3812

FSS System				Texas Instruments								
				Subscriber FM			Subscriber 52 Mbps			Hub 52 Mbps		
Name	Terminal	Data Rate	El. Angle	Mainlobe	Sidelobe	Backlobe	Mainlobe	Sidelobe	Backlobe	Mainlobe	Sidelobe	Backlobe
Teledesic	TST	T1	40	110400	3490	3490	76840	2430	2430	6103	6103	6103
Teledesic	TGT	OC24	40	9099	288	288	8873	281	281	705	705	705
Spaceway	Subscriber	T1	30	122600	3877	3877	68350	2161	2161	5429	5429	5429
ACTS	USAT	4.8 kbps	30	62870	1988	1988	35060	1109	1109	2784	2784	2784
ACTS	HDRT	622 Mbps	30	157900	4994	4994	154000	4870	4870	12230	12230	12230

6.2 FSS Earth Stations Accessing NGSO Satellites Interfering into LMDS Receivers

The analyses contained in this section investigates the interference from Teledesic Standard and GigaLink Terminals into the LMDS subscriber terminals and hub transmitters based upon the system and antenna characteristics provided by Teledesic and LMDS proponents.

In performing the analyses, the goal was to determine the area within an LMDS cell in which the Teledesic Standard Terminal and the Teledesic GigaLink Terminal could operate without causing the C/(N+I) to any LMDS user within the cell from exceeding its minimum acceptable value. The Teledesic Standard Terminal assumes a T1 rate user, and the Teledesic GigaLink Terminal assumes an OC-24 rate user. It was also assumed that the interference power spectral density simply increases the background noise temperature at the receiver of the desired user.

The interference from both the Teledesic Standard Terminal and the Teledesic GigaLink Terminal into the hub to subscriber and the subscriber to hub links for CellularVision, VideoPhone, TI System 1, and TI System 3 users were considered. In the CellularVision application, the hub to subscriber link employs FM while the subscriber to hub link employs digital modulation. In the VideoPhone application, AM, FM, and digital modulation are supported. Texas Instruments' LMDS system consists of four services, System 1, System 2, System 3, and System 4. System 1 and System 2 both employ digital QPSK modulation with different data rates. System 3 employs FM and System 4 employs AM.

The analyses consist of two steps. In the first step, a single user was put at the edge of a circular LMDS cell centered on an LMDS hub transmitter. Based upon the link parameters and the directivity of antennas, the areas within the cell were identified where the TST and the TGT could operate. The analyses assumes that the subscriber on the cell edge is pointed toward the center of the cell where the hub transmitter is located. The Teledesic Standard Terminal operates its antenna above a 40 degree elevation angle. The sidelobe discrimination of the TST antenna was taken into account in determining cell area availability.

Since these analyses are based upon a circular cell design, the results can be applied symmetrically to any other point at the cell edge. In the second step of the analyses, the results were generalized to compute the cell area availability as a varying number of subscribers are placed randomly within the cell. The intersection of all of the available calculated cell areas will provide an indication of the amount of the LMDS cell area available to either the TST or the TGT as a function of LMDS users.

Figures 6.2-1 through 6.2-16 depict the results of the analyses. Two plots are shown for each interference scenario, one under clear sky conditions and the other under heavy rain conditions. Each plot contains a two dimensional map of the LMDS cell centered on the hub antenna. The cell size will vary between 1 mile radius and 3 miles radius depending upon the service being considered. The plots contain a depiction of the area where a TST or TGT may not operate without causing unacceptable interference to the single LMDS user located at the cell edge.

A summary of the link parameters for the service link and for the interference link which were used to determine cell availability is listed with each set of plots. The required C/(N+I) as defined by each service application is also listed.

Note that the Teledesic terminals increase their EIRP by 17.1 dB in order to compensate for rain attenuation. Thus for the most part, unless the particular service application also increases transmitted EIRP to compensate for rain attenuation, the cell availability will be worse under the heavy rain conditions. Since a TGT employs a larger antennae than a TST, a TGT provides better sidelobe discrimination than a TST at the 40 degree elevation angle off boresight angle and consequently less interference.

The affected areas which preclude TGT or TST operation, in most cases, extends beyond the cell area being considered into the adjacent cell areas, especially along the boresight of the receiving antenna. For this reason, in addition to computing the percentage cell area availability, the clearances along boresight, sidelobe, and the backlobe of the receiving antenna were also calculated.

Boresight clearance refers to the distance along the boresight of the receiving antenna at which the interfering TST or TGT can be placed without causing the LMDS C/(N+I) from meeting its acceptable value. Sidelobe clearance refers to the distance along either sidelobe of the receiving antenna at which the interfering TST or TGT can be placed without causing the LMDS C/(N+I) from meeting its acceptable value. Backlobe clearance refers to distance along the back lobe of the receiving antenna at which the interfering TST or TGT can be placed without causing the C/(N+I) from meeting its acceptable value.

6.2.1. Interference Into CellularVision

6.2.1.1. TST Interference Into Cellular Vision: Hub To Subscriber

Figure 6.2-1 depicts the cell availability for the hub to single subscriber case for the CellularVision service application when a TST is considered as an interferer. The enclosed area which includes the antenna boresights between the subscriber and hub indicate regions where the TST cannot operate. With clear sky conditions, a large corridor about 1 mile in width extends through the entire cell along the line of sight wherein the Teledesic network may not operate; this results in approximately 80% cell availability. With rain conditions, this corridor expands significantly leaving only 58% cell availability. Under heavy rain conditions, the CellularVision service application's required C/(N+I) reduces from 26 dB to 13 dB and the system accepts a degraded performance. In both cases, the "interference corridors" extend beyond the 3 mile cell radius into adjacent cells. Boresight clearance requirements extend to 23.7 and 8 miles for clear sky and rain conditions, with no blocking or obstructions, respectively. The backlobe clearance area required extends into the adjacent cell. The sidelobe and backlobe clearance areas increase under heavy rain conditions for two primary reasons. First, the TST increases its transmit power by 17.1 dB while the CellularVision hub transmitter power remains the same. Second, since the TST is closer to the Hub than the LMDS subscriber terminal, the amount of rain attenuation is smaller for the TST interference signal than the LMDS desired signal.

6.2.1.2. TGT Interference Into Cellular Vision: Hub to Subscriber

Figure 6.2-2 depicts the cell availability for the hub to single subscriber case for the CellularVision service application when a TGT is considered as an interferer. The enclosed area indicates regions where the TGT cannot operate. Cell availability appears to be improved because the TGT uplink employs a larger antenna and consequently provides better sidelobe discrimination than the TST. However, the TGT interferer affects a larger number of LMDS channels, because the TGT has a larger bandwidth.

Again the CellularVision service application's required C/(N+I) reduces from 26 dB to 13 dB and the system accepts degraded performance under heavy rain conditions. And as with the TST case, the sidelobe and backlobe clearance areas increase under heavy rain conditions due to differences in relative power levels and relative rain attenuation under heavy rain conditions.

6.2.1.3. TST Interference Into Cellular Vision: Subscriber To Hub

Figure 6.2-3 depicts the cell availability for the single subscriber to hub case for the CellularVision service application when a TST is an interferer. In this case, the area in which the TST may not operate is symmetric about the hub, since the hub employs an omni-directional antenna. With clear sky conditions, the TST may not operate within a circle of about a 1/2 mile radius, affecting about 3% of the total cell area. Under rain conditions, 100% of the cell area is unavailable to any TST operation. Furthermore, the availability in adjacent cells is affected since the boresight, backlobe, and sidelobe clearance requirements extend 0.62 miles beyond the cell edge.

6.2.1.4. TGT Interference Into Cellular Vision: Subscriber To Hub

Figure 6.2-4 depicts the cell availability for the single subscriber to hub case for the CellularVision service application when an TGT is an interferer. The area in which the TGT is restricted from operation is symmetric about the cell center since the Hub receiving antenna is omni-directional. Under clear sky conditions, nearly 100% cell availability is achieved for this single user case while under heavy rain conditions about 89% cell availability is achieved.

6.2.2 Interference Into VideoPhone

6.2.2.1. TST Interference Into VideoPhone: Hub To Subscriber

Figure 6.2-5 depicts the cell availability for the hub to single subscriber case for the VideoPhone service application when a TST is an interferer. The narrow corridor, which includes the antenna line of sight between the hub and subscriber antennae, indicate regions in which the TST may not operate. Both clear sky and heavy rain conditions yield similar availability of about 95%. However, note that the boresight clearance requirements under clear sky conditions extend 4.5 miles beyond the far edge of the cell into the adjacent cells. In this case, the cell availability remains high because the VideoPhone link margin remains due to an increased transmitted power by 20 dB under heavy rain conditions.

6.22..2. TGT Interference Into VideoPhone: Hub To Subscriber

Figure 6.2-6 depicts the cell availability for the hub to single subscriber case for the VideoPhone service application when a TGT is an interferer. The narrow corridor which includes the antenna line of sight between the hub and the subscriber antennae indicate the region in which the TGT may not operate. Both clear sky and heavy rain conditions yield similar cell availability of about 99.5%.

6.2.2.3. TST Interference Into VideoPhone: Subscriber To Hub

Figure 6.2-7 depicts the cell availability for the single subscriber to hub case for the VideoPhone service application when a TST is an interferer. Under clear sky conditions, cell availability is approximately 90%. However, this cell availability reduces to 49% under heavy rain conditions. Note that the boresight clearance required extends significantly into the next 5 cells for clear sky conditions and 3 cells for heavy rain conditions.

6.2.2.4. TGT Interference Into VideoPhone: Subscriber To Hub

Figure 6.2-8 depicts the cell availability for the single subscriber to hub case for the VideoPhone service application when a TGT is an interferer. With clear sky conditions, cell availability is about 98% while under heavy rain conditions this is reduced to about 93%. Note that under heavy rain conditions, the boresight clearance requirements extend into the adjacent cell.

6.2.3. Interference Into TI-System 1

6.2.3.1. TST Interference Into TI-Sys1: Hub To Subscriber

Figure 6.2-9 depicts the cell availability for the hub to single subscriber case for the TI-System 1 service application when a TST is an interferer. Cell availability under clear sky conditions is about 98%, but is reduced to 73% under heavy rain conditions. The required boresight clearance extends into the next adjacent cell for both clear sky and heavy rain conditions. Under heavy rain conditions, the sidelobe and backlobe clearance requirements increase for the reasons described in the the CellularVision service application scenarios.

6.2.3.2. TGT Interference Into TI-Sys1: Hub To Subscriber

Figure 6.2-10 depicts the cell availability for the hub to single subscriber case for the TI-System 1 service application when a TGT an interferer. Almost 100% cell availability is achieved under clear sky conditions. Under heavy rain conditions 97% cell availability is achieved with the boresight clearance extending about 0.1 of a mile into the next adjacent cell. The sidelobe and backlobe clearances increase under heavy rain conditions.

6.2.3.3. TST Interference Into TI-Sys1: Subscriber To Hub

Figure 6.1-11 depicts the cell availability for the single subscriber to hub case for the TI-System 1 service application when a TST is an interferer. Again, the cell area which preclude TST operation is symmetric about the Hub omni-directional antennae centered at the LMDS cell. Under clear sky conditions almost 99% availability is achieved. However 0% cell availability is achieved under heavy rain conditions because the TI link margin is reduced by rain attenuation and the TST increases its power.

6.2.3.4. TGT Interference Into TI-Sys1: Subscriber To Hub

Figure 6.2-12 depicts the cell availability for the single subscriber to hub case for the TI-System 1 service application when a TGT is an interferer. Virtually 100% cell availability is achieved under clear sky conditions which is reduced to 93% under heavy rain conditions.

6.2.4. Interference Into TI-System 3

6.2.4.1. TST Interference Into TI-Sys3: Hub To Subscriber

Figure 6.2-13 depicts the cell availability for the hub to single subscriber case for the TI-System 3 service application when a TST is an interferer. Cell availability under clear sky conditions is about 97%. This is reduced to 72% under heavy rain conditions with boresight, sidelobe, and backlobe clearance requirements extending into the adjacent cells. The sidelobe and backlobe clearances increase for the same described in the TI-System 1 and CellularVision cases.

6.2.4.2. TGT Interference Into TI-Sys3: Hub to Subscriber

Figure 6.2-14 depicts the cell availability for the hub to single subscriber case for the TI-System 3 service application when a TGT is an interferer. Under clear sky conditions, the cell availability is nearly 100% while under heavy rain conditions the cell availability reduces to 97% with boresight clearance requirements extending into the adjacent cell. Again note that sidelobe and backlobe areas increase under heavy rain conditions.

6.2.4.3. TST Interference Into TI-Sys3: Subscriber to Hub

Figure 6.2-15 depicts the cell availability for the hub to single subscriber case for the TI-System 3 service application when a TST is an interferer. Under clear sky conditions, cell availability is about 99%. However, under heavy rain conditions, cell availability is 0%. As with the TI-System 3 case, the substantial difference in cell availability is due to the reduction in the link margin by the increase in TST transmitted power and rain attenuation.

6.2.4.4. TGT Interference Into TI-Sys3: Subscriber To Hub

Figure 6.2-16 depicts the cell availability for the single subscriber to hub case for the TI-System 3 service application when a TGT is considered as an interferer. Under clear sky conditions, virtually 100% availability is achieved. Under heavy rain conditions, this cell availability reduces to 97%.

Addendum supplied by Texas Instruments relevant to Work Group 1 Report Sections 6.2.3 and 6.2.4.

This analysis does not take into account the adoption of automatic power control to overcome rain attenuation and the corresponding clear air transmitter power reduction adopted for the TI system. These two factors will decrease the clear air availability reported here.

6.2.5. Cell Area Availability To Teledesic Standard Terminals

Figures 6.2-17 through 6.2-23 illustrate the percentage of the LMDS cell area unavailable for use by Teledesic Standard Terminals and Teledesic GigaLink Terminals as a function of the number of LMDS receivers within that particular cell. Multiple LMDS receivers were randomly placed throughout the LMDS cell. For each given number of LMDS receivers and their placement, cell area availability was calculated by determining those areas of the cell in which either the Teledesic Standard Terminal or the Teledesic GigaLink Terminal could operate without causing any LMDS hub to subscriber link C/(N+I) to meet its acceptable interference value. The cell area availability was calculated under both clear sky and heavy rain conditions.

Figure 6.2-17 illustrates the cell area availability for a CellularVision LMDS cell when considering TST interference. Cell area availability diminishes to less than 20% of the cell available for use by a TST when there are 20 LMDS receivers under either clear sky or heavy rain conditions.

Figure 6.2-18 illustrates the cell area availability for a VideoPhone LMDS cell when considering TST interference. Cell area availability diminishes to less than 20% of the cell available for use by a TST when there are 150 LMDS users. Since a VideoPhone hub transmitter increases its EIRP by 20 dB to compensate for rain attenuation, the reduction of cell area availability for TST operations is more gradual under this condition.

Figure 6.2-19 illustrates the cell area availability for an LMDS cell consisting of TI System 1 users at 52 Mbps when considering TST interference. Again, the cell area availability diminishes to 20% for use by a TST when the number of LMDS users reaches 600. Under heavy rain conditions, rain attenuation on the hub to subscriber link virtually precludes the use of any Teledesic TST's within the cell.

Figure 6.2-20 illustrates the cell area availability for an LMDS cell consisting of TI System 3 users when considering TST interference. Again, the available cell area diminishes as the number of LMDS users increases. In this case, less than 20% of the cell area is available for use by a TST, when the number of LMDS users exceed 500 under clear sky conditions. With heavy rain conditions, virtually none of the cell area is available for Teledesic Standard Terminals.

Figure 6.2-21 illustrates the cell area availability for an LMDS cell consisting of CellularVision users when considering TGT interference. The cell availability diminishes but more gradually than when considering TST interference. With less than 250 LMDS users, less than 20% cell availability for TST terminals is achieved with both clear sky and heavy rain conditions.

Based on a free space loss analyses conducted, these plots indicate that without structural blockage, foliage, attenuation, reflections and other factors, the presence of a relatively few number of lmds users within an LMDS cell can significantly reduce the available area that a TST may operate. Furthermore, under heavy rain conditions, the TST user may be precluded from operation in any part of the LMDS cell. The presence of some 500 LMDS users can effectively prevent operation for the TST's in a geographic area. OC-24 TGT operation will similarly be restricted significantly, especially under heavy rain conditions. Free space path loss equations may not accurately reflect the magnitude of actual FSS interferences into LMDS.

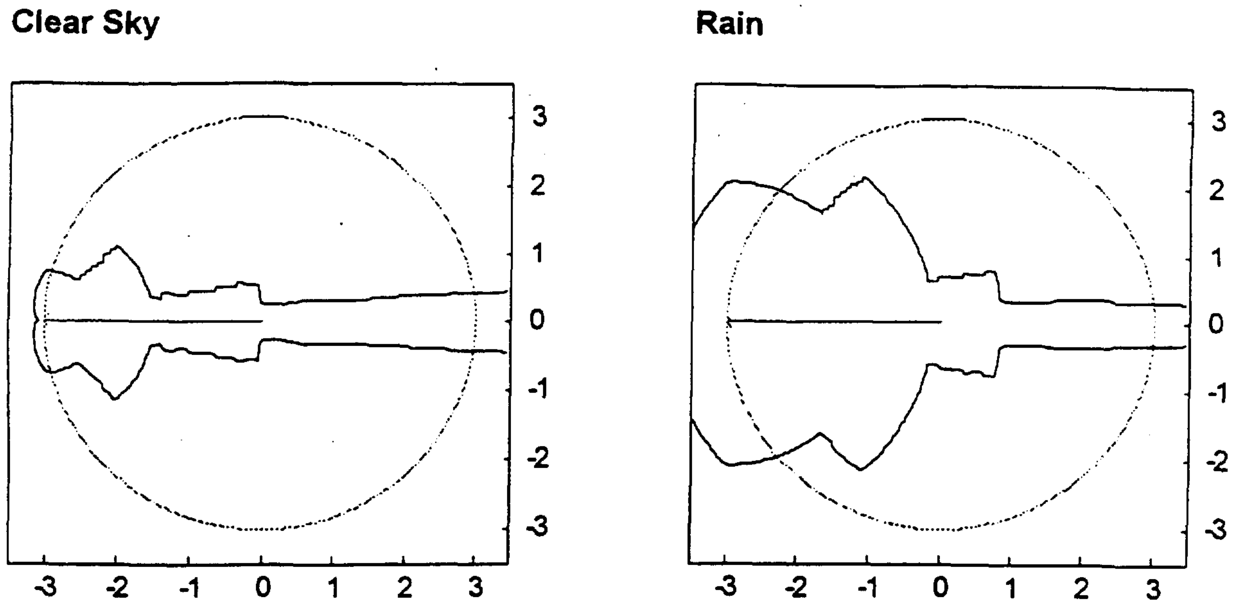


Figure 6.2-1 T1 TST into CellularVision hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-4.00	0.85
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	12.00	36.00
Signal Bandwidth (MHz)	18.00	26.50
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	31.00	
Noise Temperature (dB°K)	30.65	
Required C/(N+I) (dB)	26.00(13.00)	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	23.7	8.00
Sidelobe (45°) min. Clearance (mile)	1.50	2.88
Backlobe min. Clearance (mile)	0.0751	0.494
Cell Availability (% of a cell)	79.7	57.7

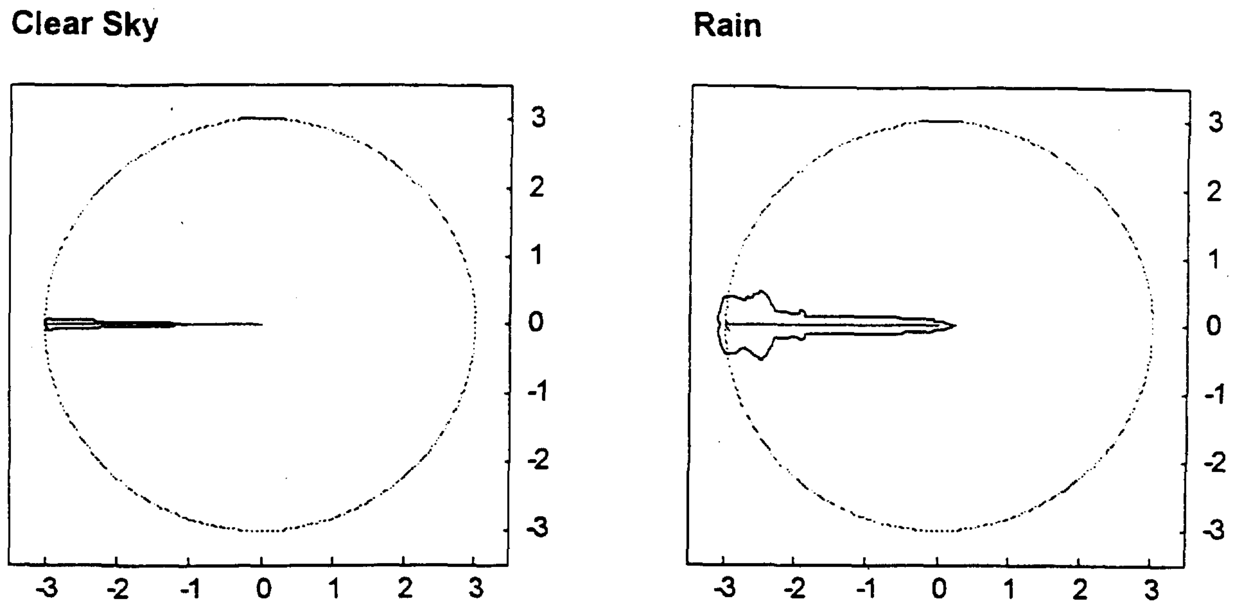


Figure 6.2-2 OC-24 TGT into CellularVision hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-4.00	-0.18
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	12.00	50.00
Signal Bandwidth (MHz)	18.00	800.00
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	31.00	
Noise Temperature (dB°K)	30.65	
Required C/(N+I) (dB)	26.00(13.00)	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	1.96	3.23
Sidelobe (45°) min. Clearance (mile)	0.123	0.714
Backlobe min. Clearance (mile)	0.00619	0.0537
Cell Availability (% of a cell)	99.5	96.0

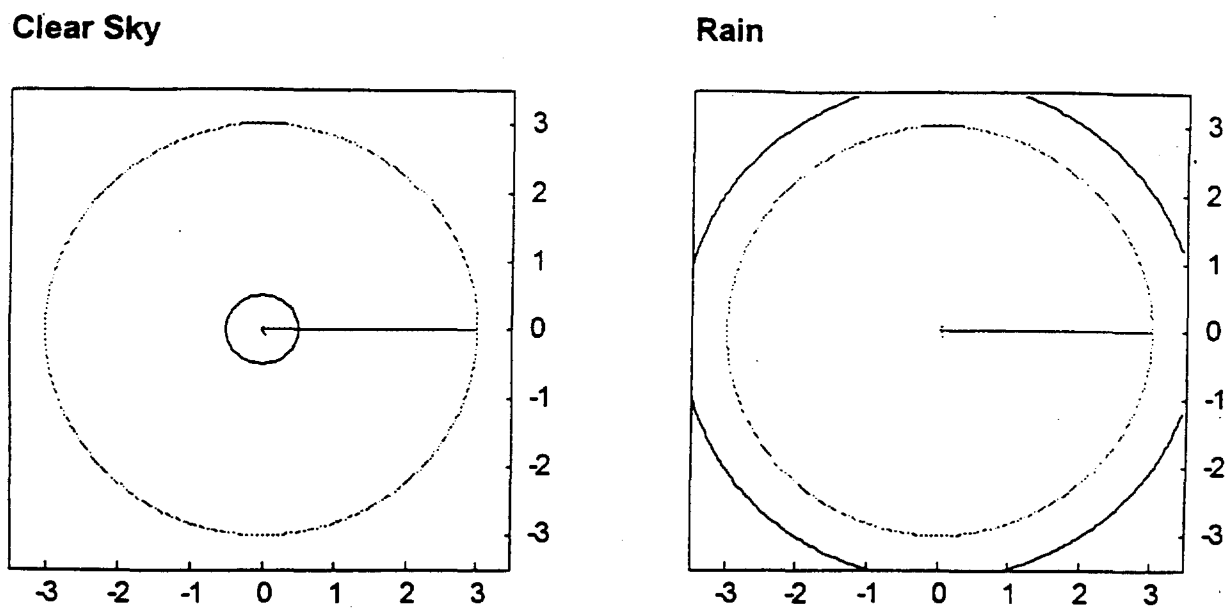


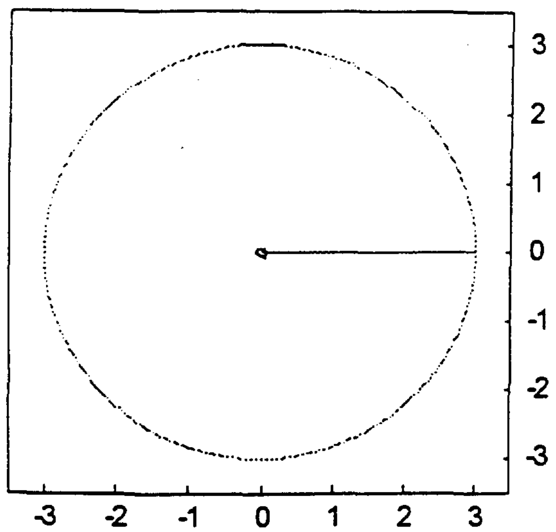
Figure 6.2-3 T1 into CellularVision subscriber-to-hub link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-29.00	0.85
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	31.00	36.00
Signal Bandwidth (MHz)	0.04	26.50
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	12.10	
Noise Temperature (dB°K)	27.68	
Required C/(N+I) (dB)	16.00	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	0.504	3.62
Sidelobe (45°) min. Clearance (mile)	0.504	3.62
Backlobe min. Clearance (mile)	0.504	3.62
Cell Availability (% of a cell)	97.2	0.0



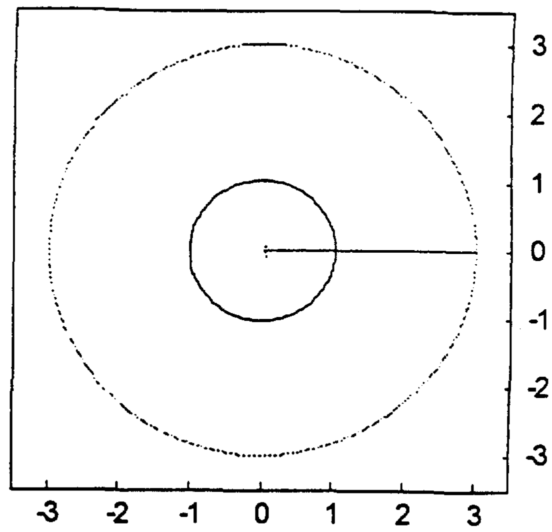


Figure 6.2-4 TGT into CellularVision subscriber-to-hub link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-29.00	-0.18
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	31.00	50.00
Signal Bandwidth (MHz)	0.04	800.00
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	12.10	
Noise Temperature (dB°K)	27.68	
Required C/(N+I) (dB)	16.00	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	0.0416	1.03
Sidelobe (45°) min. Clearance (mile)	0.0416	1.03
Backlobe min. Clearance (mile)	0.0416	1.03
Cell Availability (% of a cell)	99.9	88.3

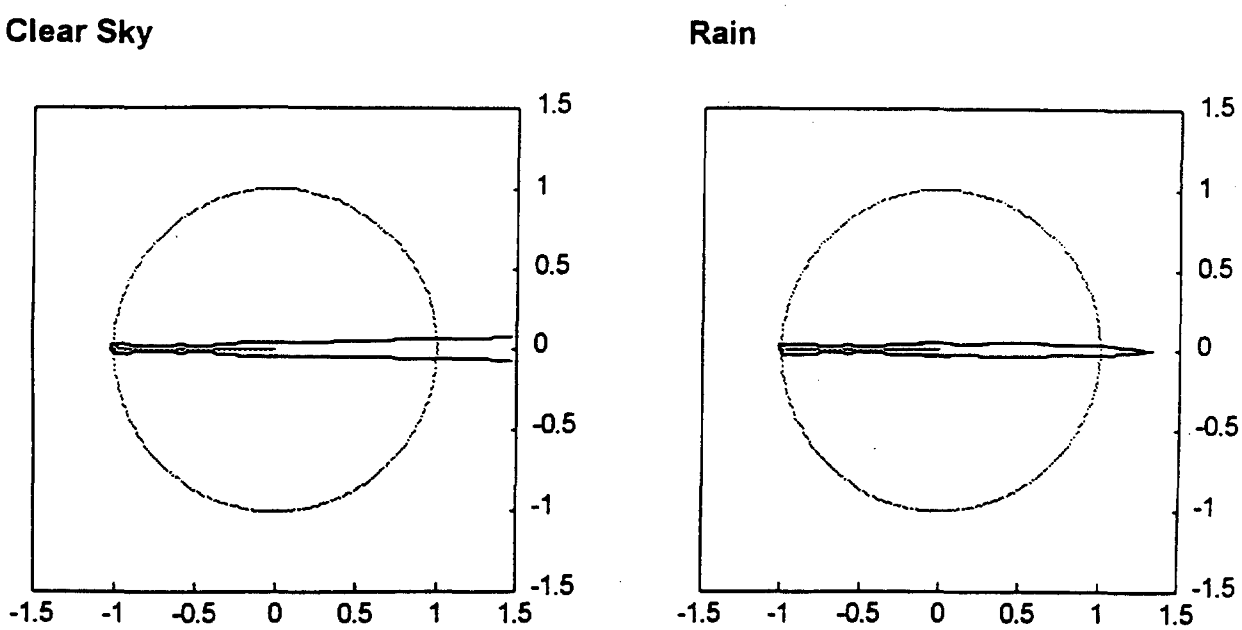


Figure 6.2-5 TST into Video/Phone hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	1.00	
Transmit Power (dBW)	-10.00	0.85
Power Increase in Rain (dB)	20.00	17.10
Transmit Antenna Peak Gain (dBi)	37.00	36.00
Signal Bandwidth (MHz)	20.00	26.50
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	38.20	
Noise Temperature (dB°K)	31.49	
Required C/(N+I) (dB)	45.80	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	6.53	2.33
Sidelobe (45°) min. Clearance (mile)	0.0306	0.0388
Backlobe min. Clearance (mile)	0.0164	0.0210
Cell Availability (% of a cell)	95.1	95.6

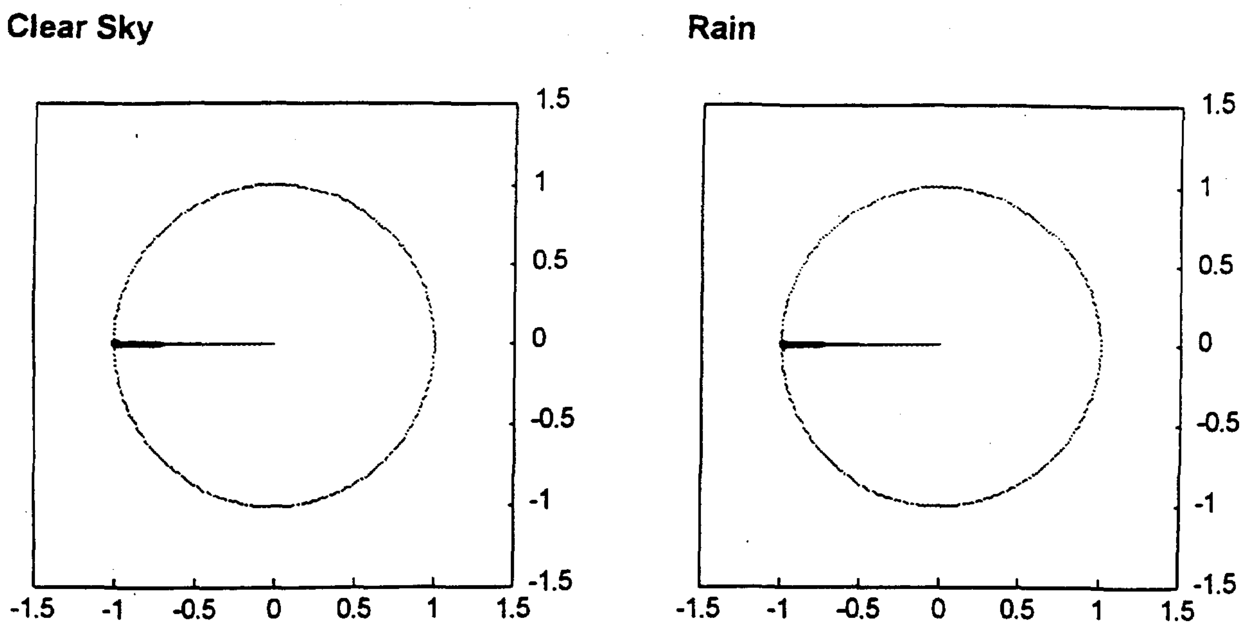


Figure 6.2-6 TGT into Video/Phone hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	1.00	
Transmit Power (dBW)	-10.00	-0.18
Power Increase in Rain (dB)	20.00	17.10
Transmit Antenna Peak Gain (dBi)	37.00	50.00
Signal Bandwidth (MHz)	20.00	800.00
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	38.20	
Noise Temperature (dB°K)	31.49	
Required C/(N+I) (dB)	45.80	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	0.539	0.509
Sidelobe (45°) min. Clearance (mile)	0.00253	0.00328
Backlobe min. Clearance (mile)	0.00135	0.00176
Cell Availability (% of a cell)	99.5	99.5

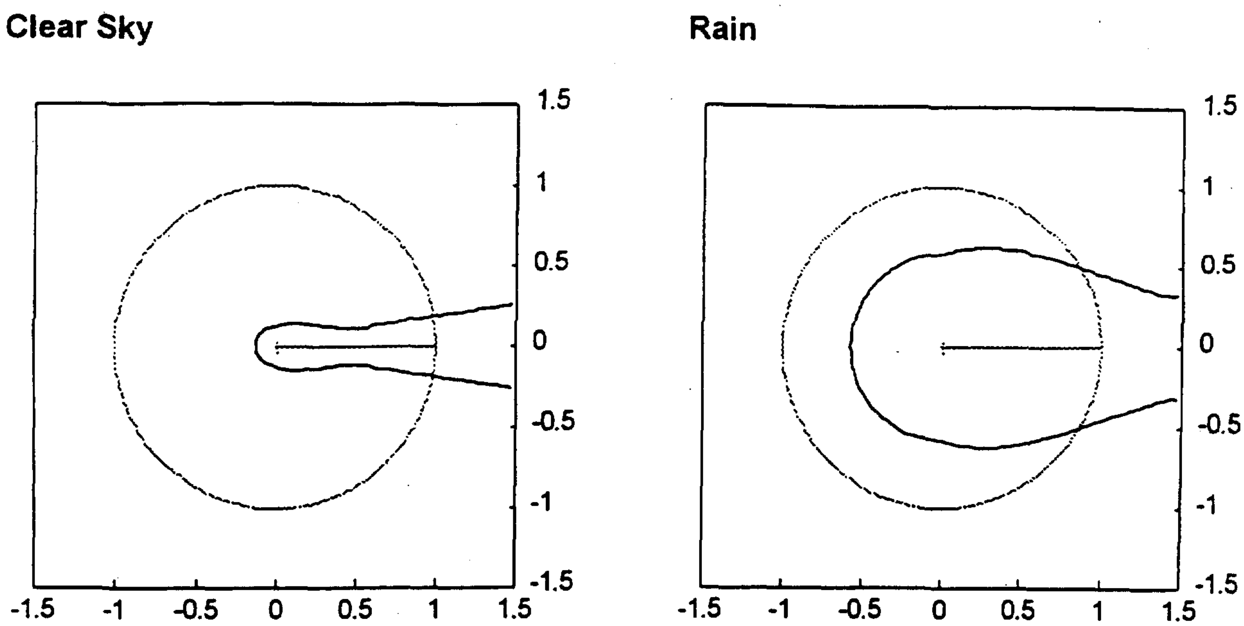


Figure 6.2-7 TST into Video/Phone subscriber-to-hub link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	1.00	
Transmit Power (dBW)	-16.00	0.85
Power Increase in Rain (dB)	5.80	17.10
Transmit Antenna Peak Gain (dBi)	38.20	36.00
Signal Bandwidth (MHz)	22.50	26.50
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	37.00	
Noise Temperature (dB°K)	30.38	
Required C/(N+I) (dB)	44.20	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	10.1	5.43
Sidelobe (45°) min. Clearance (mile)	0.203	0.823
Backlobe min. Clearance (mile)	0.123	0.575
Cell Availability (% of a cell)	90.6	49.5

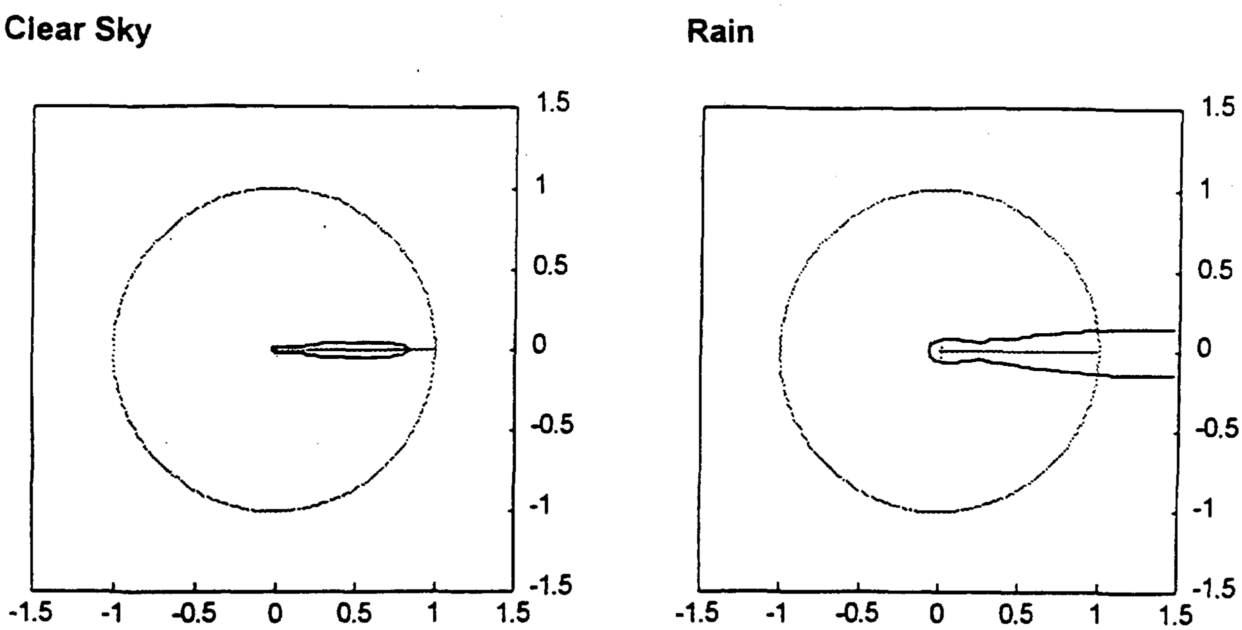


Figure 6.2-8 TGT into Video/Phone subscriber-to-hub link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	1.00	
Transmit Power (dBW)	-16.00	-0.18
Power Increase in Rain (dB)	5.80	17.10
Transmit Antenna Peak Gain (dBi)	38.20	50.00
Signal Bandwidth (MHz)	22.50	800.00
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	37.00	
Noise Temperature (dB°K)	30.38	
Required C/(N+I) (dB)	44.20	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	0.836	1.90
Sidelobe (45°) min. Clearance (mile)	0.0167	0.105
Backlobe min. Clearance (mile)	0.0101	0.065
Cell Availability (% of a cell)	98.1	93.8